Consensus Study Report
HIGHLIGHTS
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Advanced Technologies for Gas Turbines

In the United States, gas turbines power all large airplanes and generate about one-third of the electricity used by the national power grid. Over at least the next two decades, gas turbines will continue to dominate the aviation industry, and demand for gas turbines for power generation is projected to increase both in the United States and around the world until renewable energy systems can replace traditional power plants on a large scale. Therefore, continuing leadership in gas turbine technologies is of economic importance to the United States. At the request of the Department of Energy (DOE), the National Academies organized a study to explore opportunities for improving the efficiency and life cycle cost of gas turbines over the next decade. This report identifies high-priority goals and research areas that the DOE, government agencies, industry, and academia should pursue in order to improve and develop advanced technologies for gas turbines. Applications considered in this report include gas turbines for power generation, aviation, and the oil and gas industry.

HIGH-PRIORITY GOALS FOR POWER GENERATION GAS TURBINES

- Substantially ***improve turbine efficiency***.
- ***Increase compatibility with renewable energy sources and storage systems*** by reducing turbine start-up times and improving the ability to accommodate flexible power demands.
- ***Reduce CO_2 emissions*** to as close to zero as possible, while also meeting standards for other harmful emissions.
- ***Increase fuel flexibility*** by enabling gas turbines to operate with high proportions of hydrogen or other renewable gas fuels.
- ***Reduce levelized cost of electricity from power generation gas turbines*** to remain competitive with the cost of solar and wind power over the long term.

HIGH-PRIORITY GOAL FOR AVIATION GAS TURBINES

- ***Enable a 25 percent reduction in fuel burn*** by improving fuel efficiency relative to today's best-in-class turbofan engines.

HIGH-PRIORITY GOALS FOR OIL AND GAS INDUSTRY GAS TURBINES[1]

- ***Increase fuel flexibility*** by enabling gas turbines to operate with high proportions of hydrogen or other renewable gas fuels.
- ***Increase periods of uninterrupted operation*** to 3 years or more without reducing availability or reliability.
- ***Design gas turbines for flexible power demand*** that can handle large load swings and operate at partial load with greater efficiency than electric motors.

[1] *These goals apply to gas turbines in pipeline compressor stations as well as other relevant oil and gas applications.*

HIGH-PRIORITY RESEARCH AREAS FOR GAS TURBINES

- Enhance foundational knowledge needed for ***low-emission combustion systems*** that can work in high-pressure, high-temperature environments and operate across a range of power settings and fuel compositions.
- Develop advanced ***structural materials and coatings*** to improve gas turbine efficiency and reduce development time and life cycle costs.
- Integrate ***additive manufacturing*** with existing manufacturing methods to improve and accelerate gas turbine design, increase component yield, and reduce performance variability.
- Improve ***thermal management*** by developing advanced cooling strategies to increase turbine efficiency while meeting operational lifetime requirements.
- Develop ***high-fidelity integrated simulations and validation experiments*** to enable detailed engineering analysis early in the design process.
- Investigate ***unconventional thermodynamic cycles*** for simple and combined cycle gas turbines to improve thermal efficiency.
- Improve ***system integration*** in conventional gas turbine architecture to increase performance and enable new applications.
- Develop advanced technologies for ***condition-based operations and maintenance*** of gas turbines in order to reduce scheduled and unscheduled shutdowns.
- Generate enhanced ***digital twins and supporting infrastructure*** to effectively model turbine performance and operation.
- Improve the ability of ***gas turbines in pipeline applications*** to operate efficiently under partial load and to operate safely using high proportions of hydrogen in the fuel mix.

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